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Tsuno

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(54) **GRINDING WHEEL AND CLEANING METHOD FOR GRINDING CHAMBER**

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(73) Assignee: **Disco Corporation**, Tokyo (JP)

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(51) **Int. Cl.**

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B08B 9/00	(2006.01)
B08B 9/093	(2006.01)
B08B 1/00	(2006.01)
B24B 53/007	(2006.01)
B24D 7/18	(2006.01)

(52) **U.S. Cl.**

CPC ***B24B 53/007*** (2013.01); ***B08B 3/02*** (2013.01); ***B08B 9/00*** (2013.01); ***B24D 7/18*** (2013.01); *B08B 1/007* (2013.01); *B08B 9/093* (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

A grinding wheel includes an annular base and a plurality of abrasive members fixed to the lower surface of the base and arranged annularly. The base has a plurality of through holes for discharging a grinding water. The plural through holes radially extend from the inner side surface to the outer side surface of the base. The plural through holes are arranged at given intervals in the circumferential direction of the base so that the grinding water is scattered in different directions from the through holes.

1 Claim, 5 Drawing Sheets

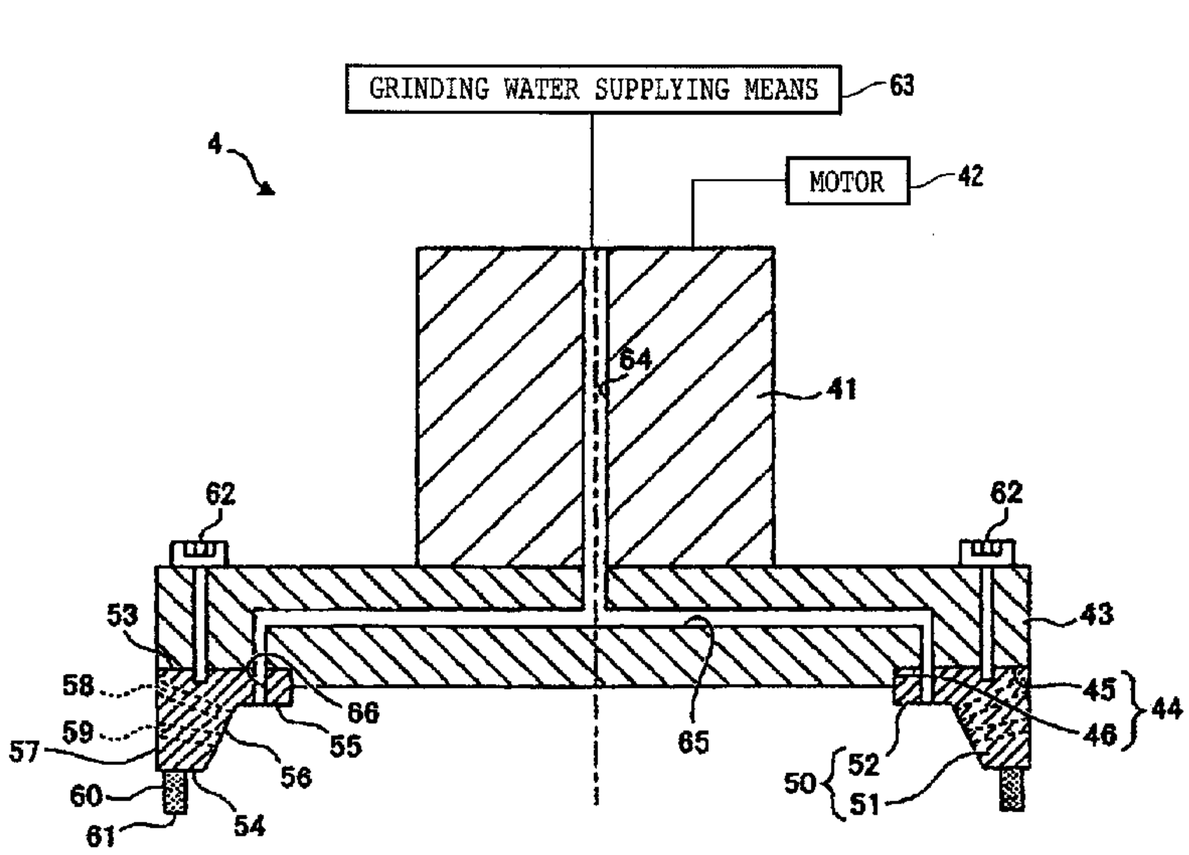


FIG. 1A

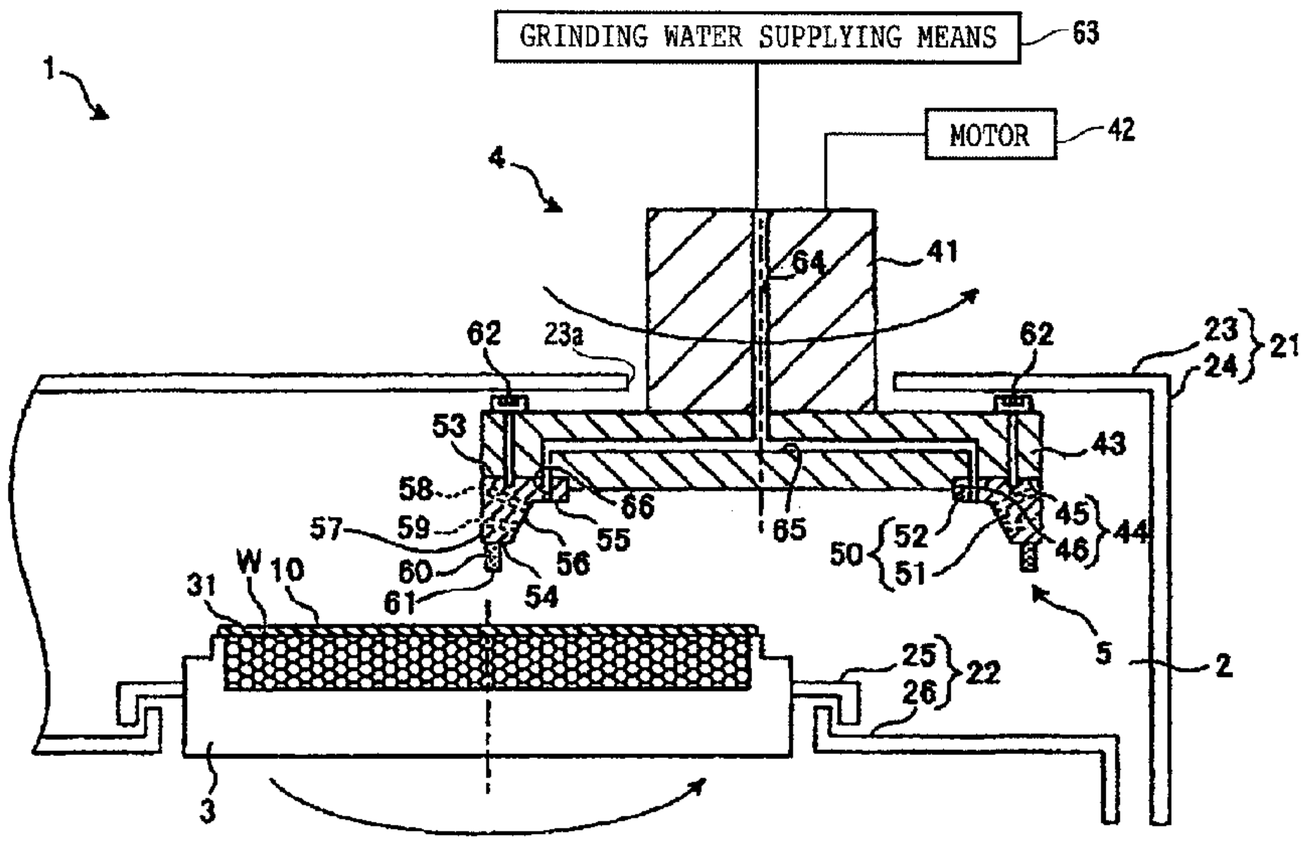

GRINDING WATER SUPPLYING MEANS
63
MOTOR
42
1
4
64
41
62
23a
62
23
24
21
53
43
58
66
57
59
55
65
45
44
52
50
46
51
60
56
W
10
31
61
54
5
2
25
22
26
3

FIG. 1B

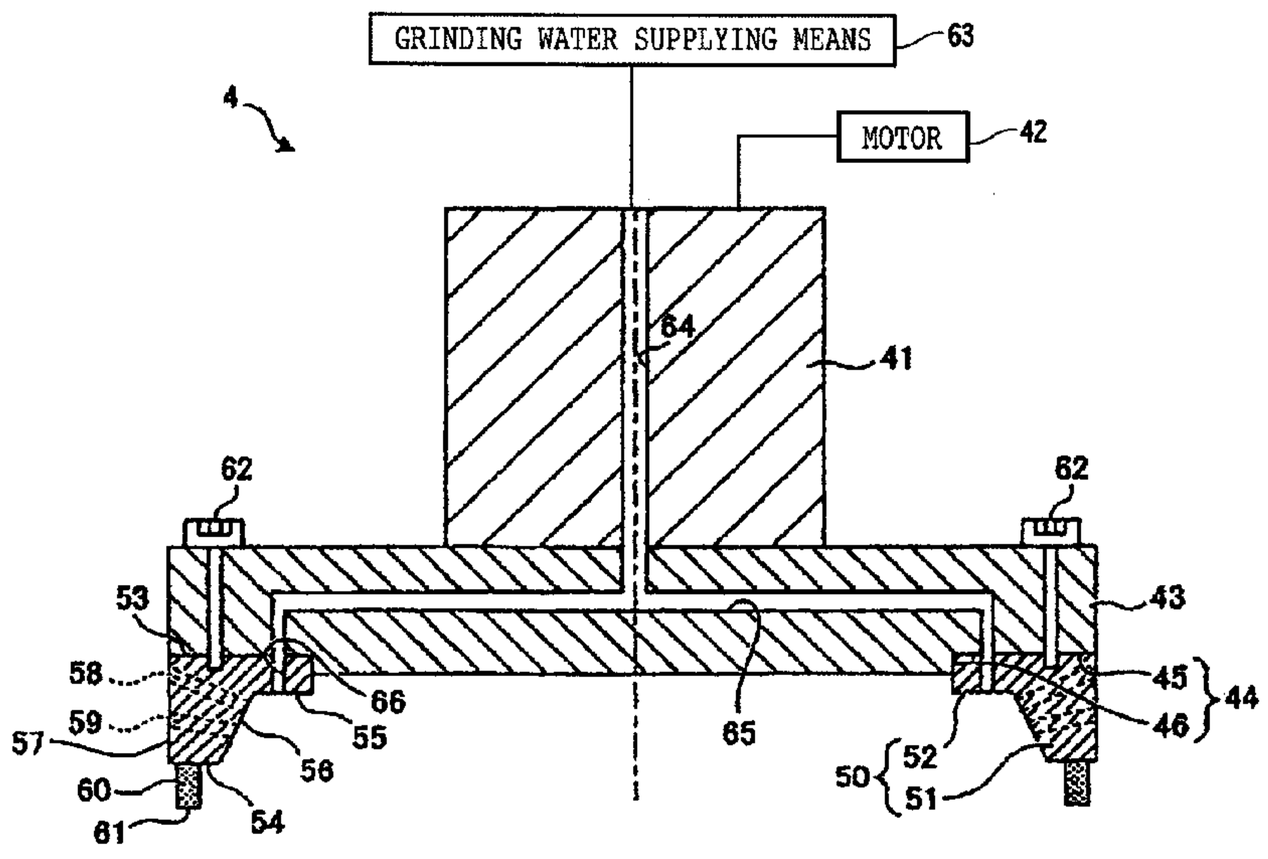

GRINDING WATER SUPPLYING MEANS
63
4
MOTOR
42
64
41
62
62
53
43
58
66
45
44
57
59
55
65
46
52
50
56
51
60
61
54

FIG.2A

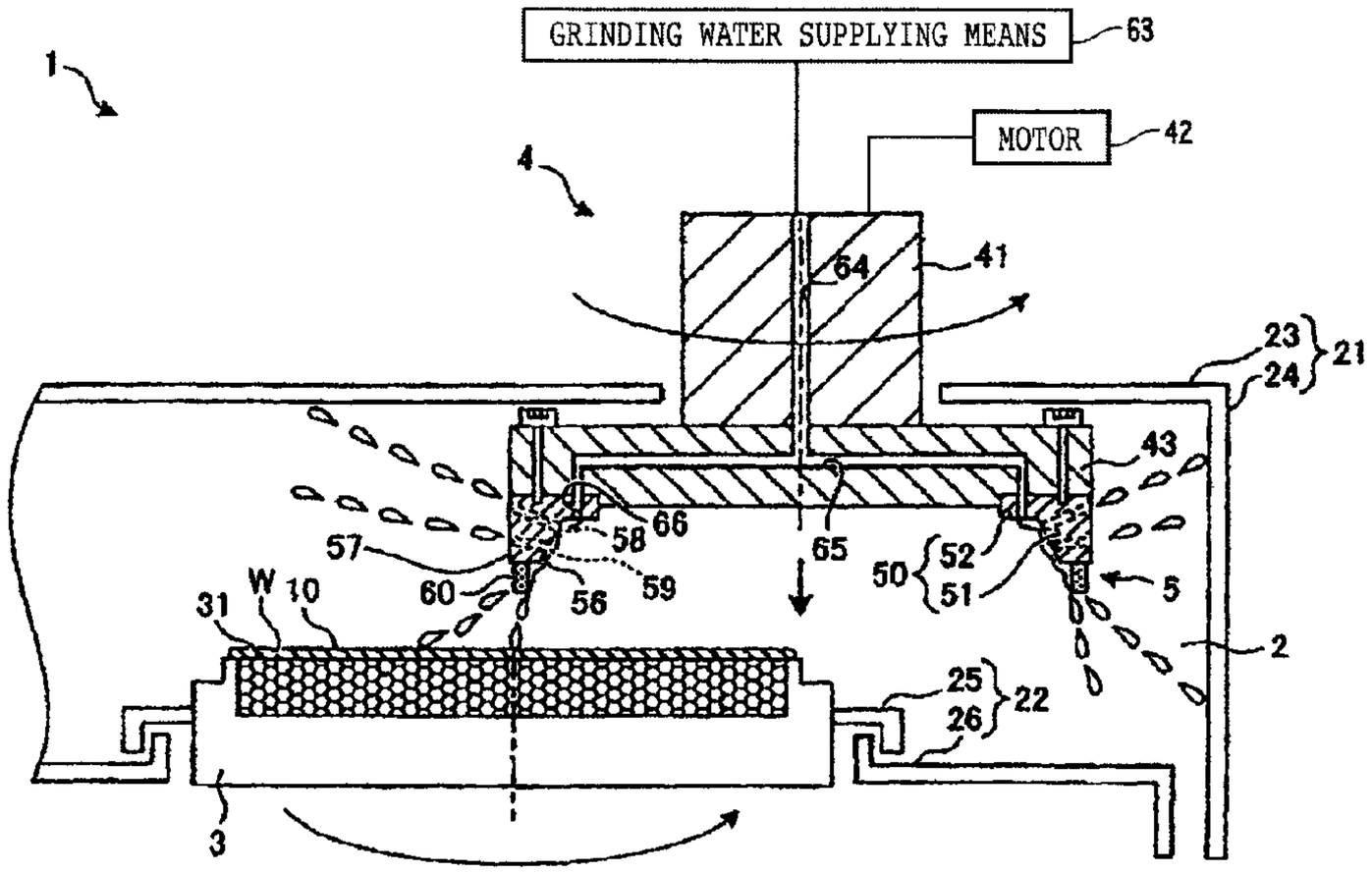

GRINDING WATER SUPPLYING MEANS
63
MOTOR
42
1
4
64
41
23
24
21
43
66
58
57
65
52
50
51
59
60
56
W
10
31
5
2
25
26
22
3

FIG.2B

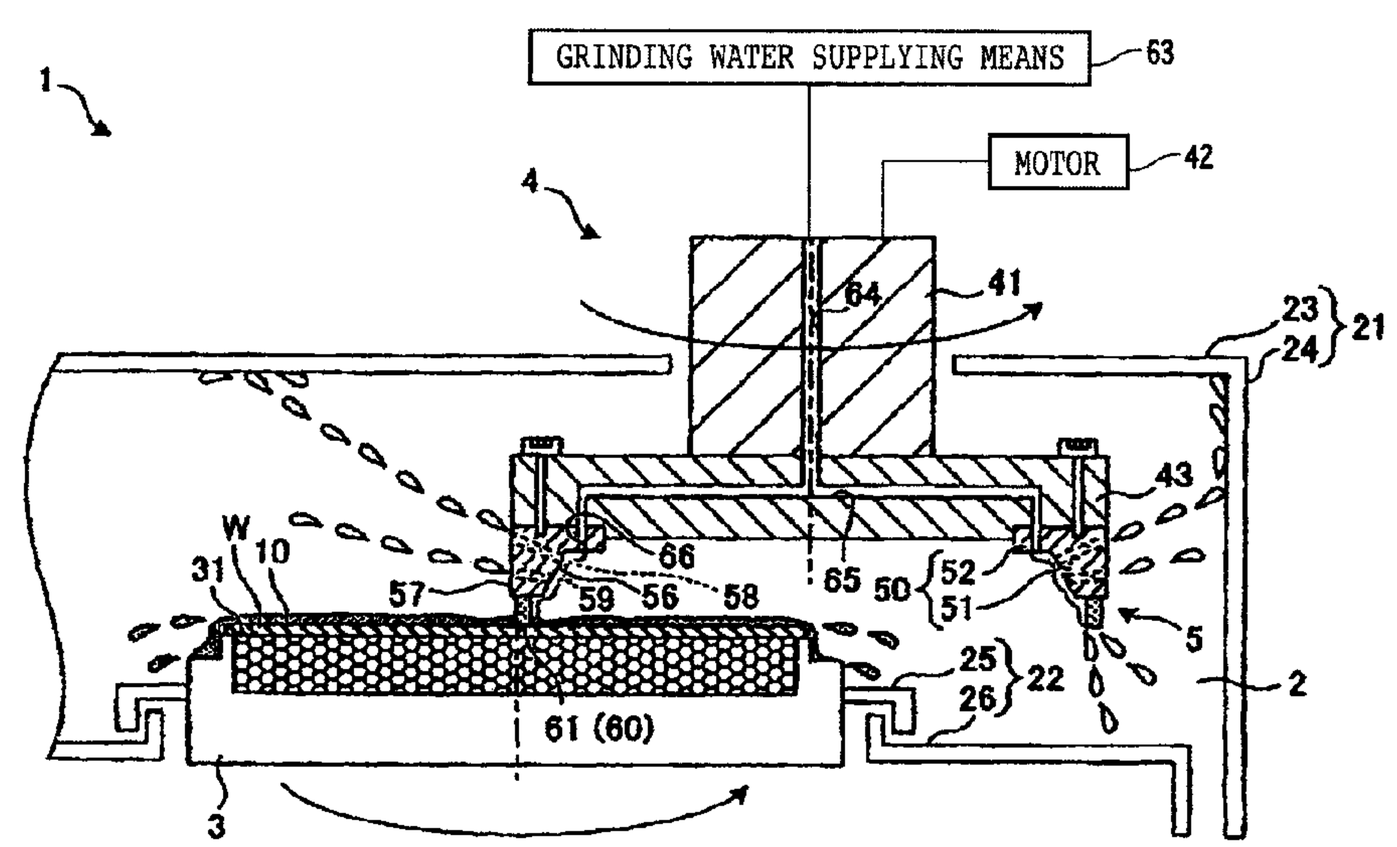

GRINDING WATER SUPPLYING MEANS
63
MOTOR
42
1
4
64
41
23
24
21
43
W
10
31
66
57
59
56
58
65
50
52
51
5
2
25
26
22
61 (60)
3

FIG.3A PRIOR ART

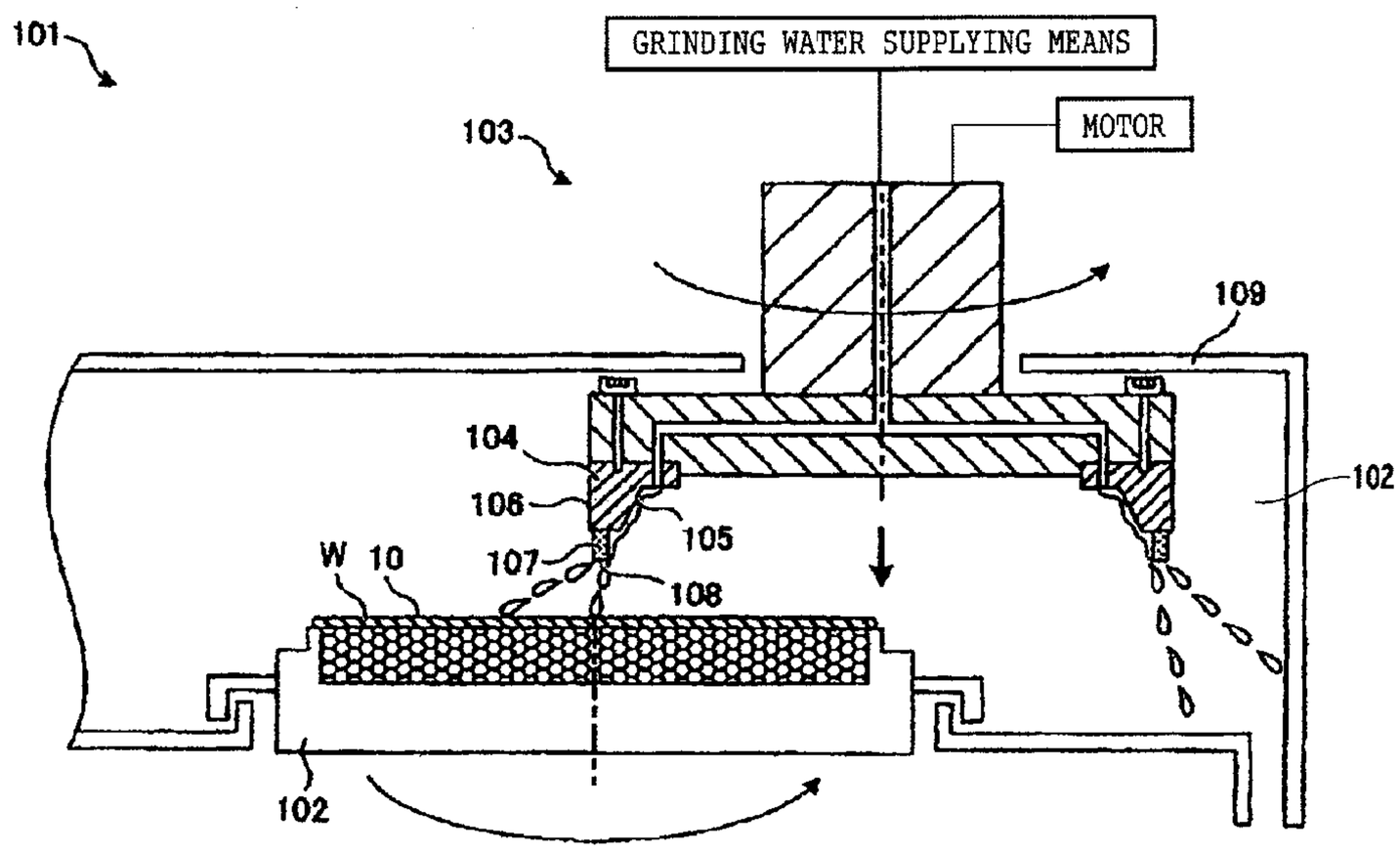


FIG.3B PRIOR ART

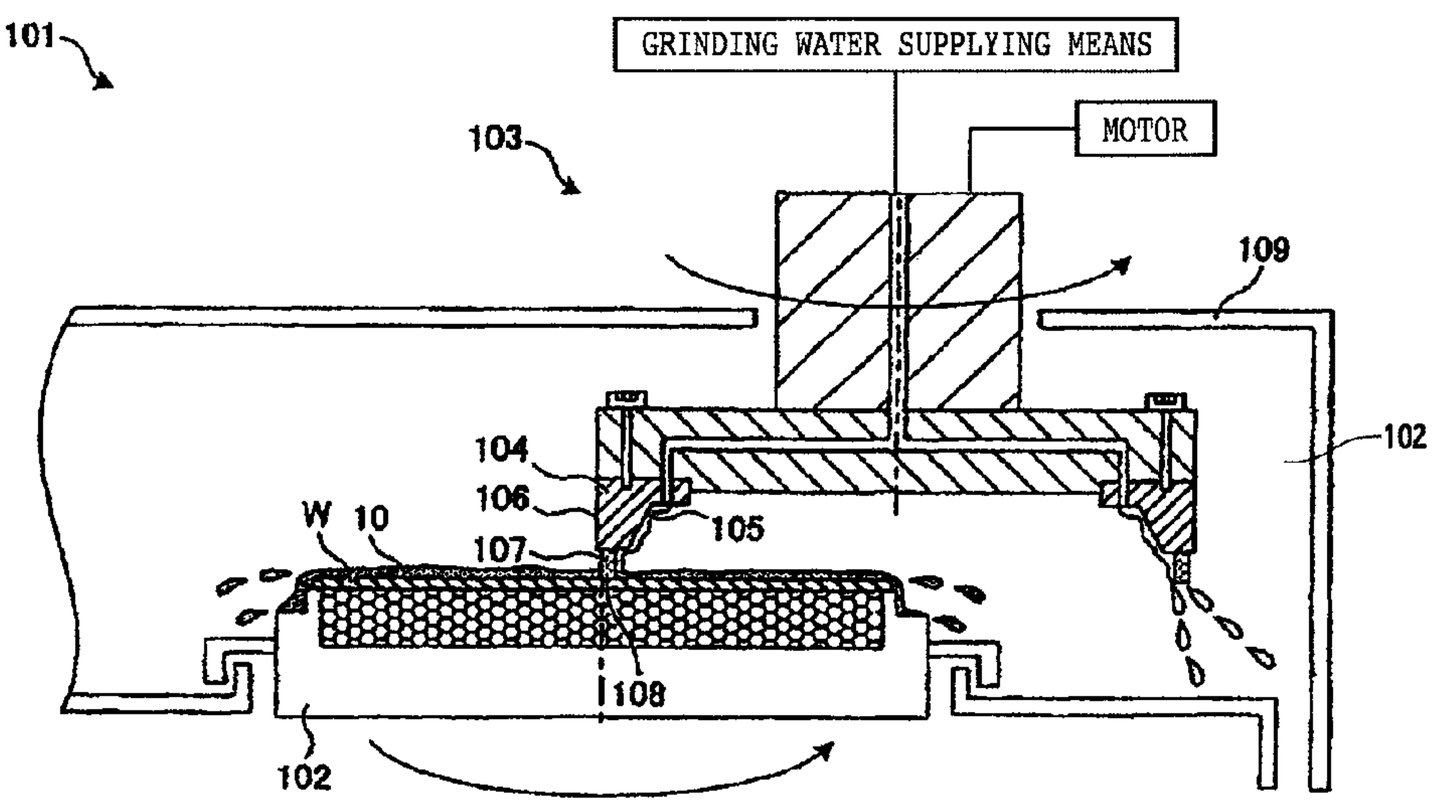


FIG. 4A

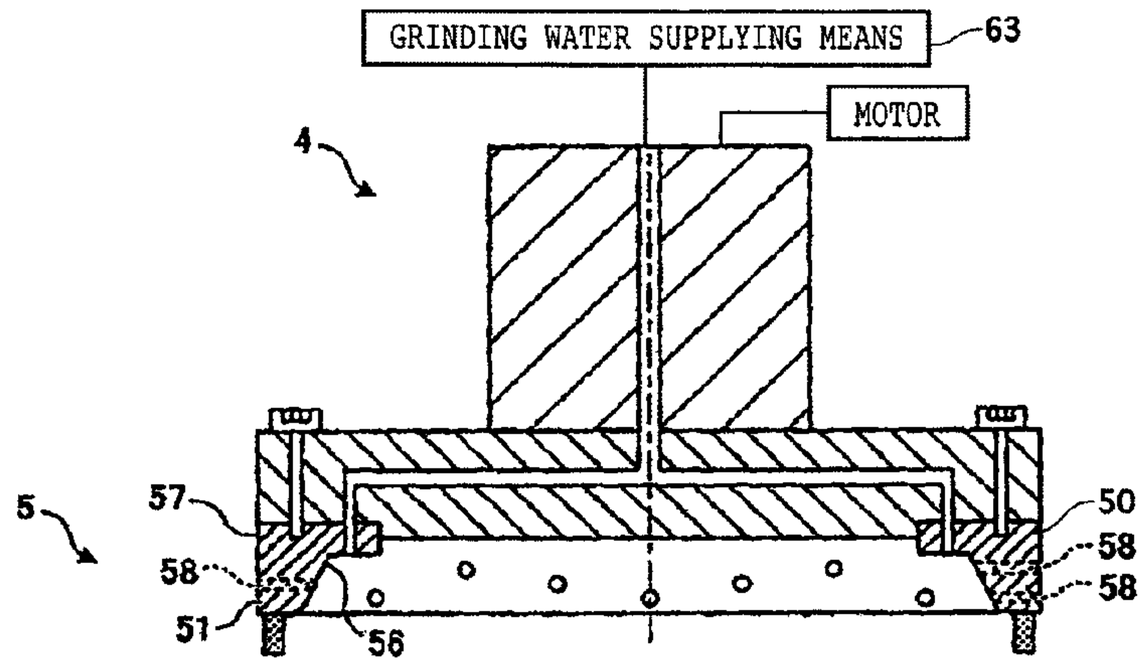


FIG. 4B

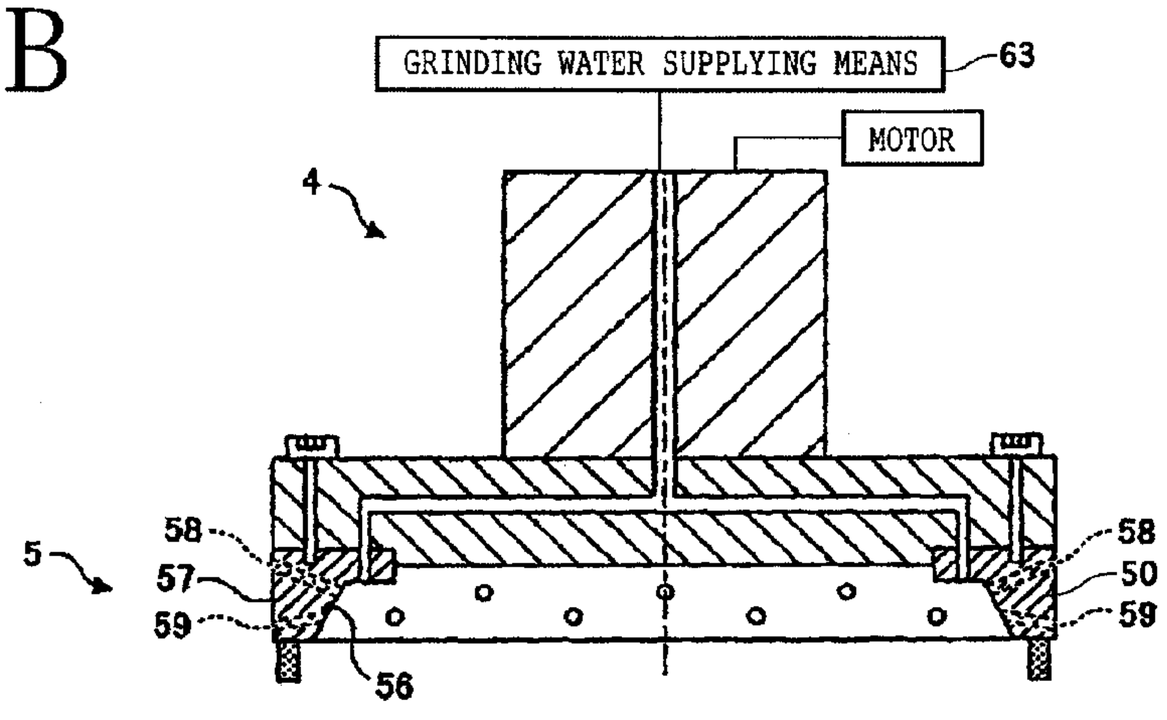


FIG. 4C

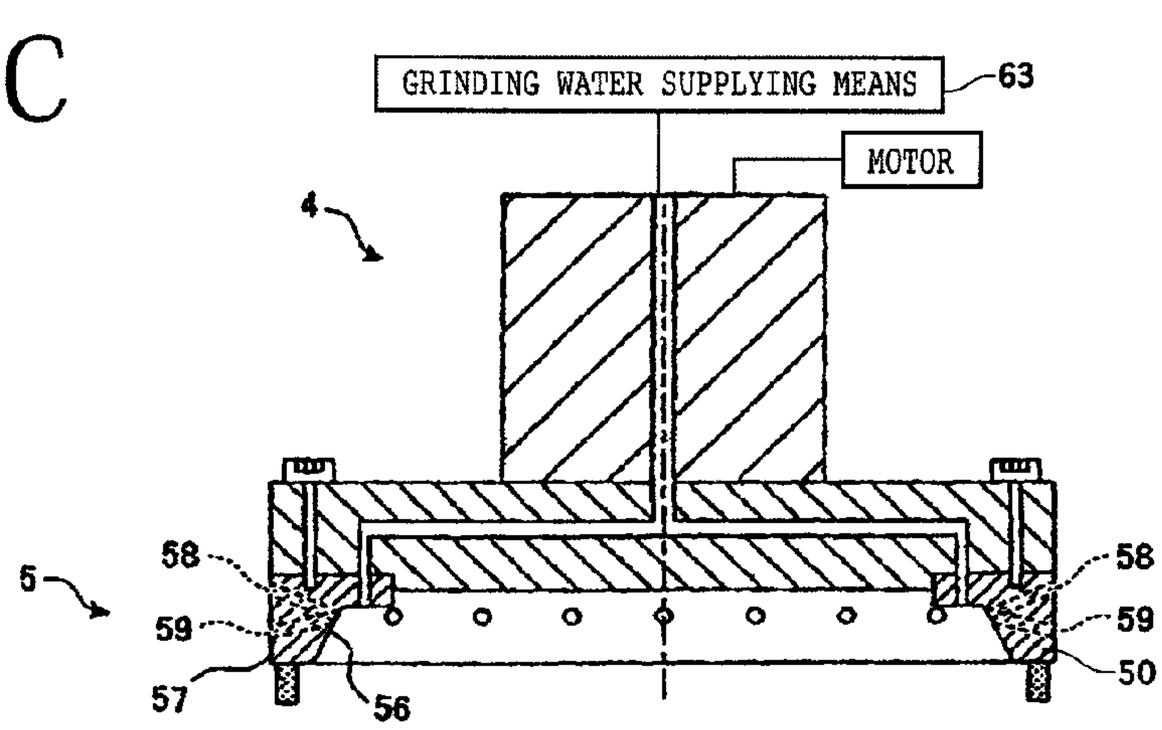
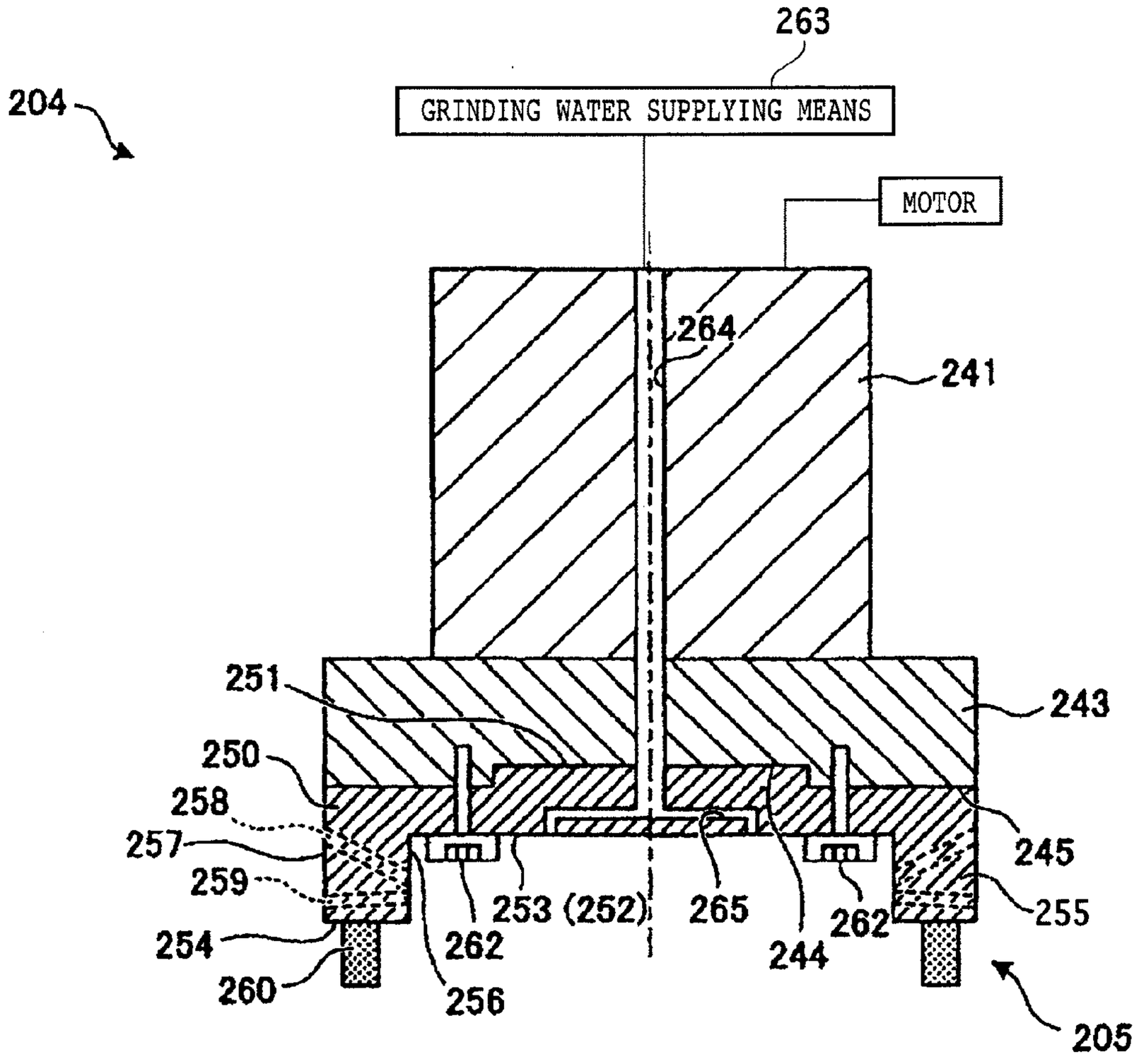


FIG.5


204
263
GRINDING WATER SUPPLYING MEANS
MOTOR
264
241
251
243
250
258
257
259
245
255
253 (252)
265
262
254
262
244
260
256
205

GRINDING WHEEL AND CLEANING METHOD FOR GRINDING CHAMBER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a grinding wheel for use in a grinding apparatus for grinding a workpiece such as a semiconductor wafer and also to a cleaning method for a grinding chamber included in the grinding apparatus.

Description of the Related Art

In a grinding apparatus, grinding is conventionally performed in the condition where a grinding water is supplied. The grinding water is supplied along the inner circumferential surface of a grinding wheel having plural abrasive members (see Japanese Patent Laid-open No. 2013-141738, for example). In the grinding apparatus described in Japanese Patent Laid-open No. 2013-141738, the grinding wheel has an annular base, and the plural abrasive members are mounted on the lower surface of the base so as to be spaced at given intervals in the circumferential direction of the base. The grinding water flows along the inner circumferential surface (inner side surface) of the base toward the abrasive members and then enters the spacing between the grinding surface of each abrasive member and the work surface of the workpiece during grinding. A grinding dust is generated during grinding and it is contained in the grinding water. The grinding water thus containing the grinding dust is forcibly moved toward the outer circumference of the workpiece through the gap between any adjacent ones of the abrasive members by a centrifugal force of the like.

SUMMARY OF THE INVENTION

The grinding wheel and a holding table for holding the workpiece are provided in a grinding chamber included in the grinding apparatus. During grinding, the grinding water containing the grinding dust is scattered in the grinding chamber due to the rotation of the grinding wheel and the holding table, so that the grinding water containing the grinding dust sticks to the inner wall of the grinding chamber. Furthermore, the grinding water containing the grinding dust is bounced from the upper surface (work surface) of the workpiece to form a mist, which floats in the grinding chamber and sticks to the inner wall of the grinding chamber. There is a possibility that the grinding water containing the grinding dust may drop from the inner wall of the grinding chamber onto the upper surface of the workpiece. In the case that the grinding dust is a large grinding dust generated during rough grinding, there is a possibility that finish grinding may be performed in the condition where this large grinding dust has dropped on the upper surface of the workpiece, causing a problem such that abrasive members for finish grinding may be damaged.

Further, when the grinding water containing the grinding dust sticks to the inner wall of the grinding chamber and this condition is allowed to stand for a long time, the particles of the grinding dust contained in the grinding water may be combined with each other to form a large grinding dust. As a result, the large grinding dust may drop by gravity from the inner wall of the grinding chamber to the upper surface of the workpiece, causing damage to the workpiece or the abrasive members.

It is therefore an object of the present invention to provide a grinding wheel and a cleaning method for a grinding chamber which can prevent the adhesion of the grinding dust to the work surface of the workpiece.

In accordance with an aspect of the present invention, there is provided a grinding wheel adapted to be mounted on a wheel mount connected to a spindle having a rotational axis extending in a vertical direction to grind a workpiece, the grinding wheel including: an annular base having an upper surface as a mounted surface to be mounted on a mounting surface of the wheel mount, a lower surface formed below the upper surface and adapted to be opposed to the workpiece, an inner side surface connecting the inner end of the upper surface and the inner end of the lower surface, and an outer side surface connecting the outer end of the upper surface and the outer end of the lower surface; and a plurality of abrasive members fixed to the lower surface of the annular base and arranged annularly for grinding the workpiece; the annular base having a plurality of through holes for discharging a grinding water, the plurality of through holes radially extending from the inner side surface to the outer side surface of the base; the through holes being arranged at given intervals in the circumferential direction of the base so that the grinding water is scattered in different directions from the through holes.

With this configuration, a part of the grinding water supplied toward the abrasive members is guided along the inner side surface of the base and introduced into the through holes formed in the base by a centrifugal force due to the rotation of the grinding wheel. The grinding water introduced into the through holes is passed through the through holes and then discharged from the outer side surface of the base by the centrifugal force. Accordingly, the grinding water is scattered from the through holes toward a top plate and a side plate forming the grinding chamber, thereby washing away a grinding dust sticking to the top plate and the side plate of the grinding chamber. As a result, it is possible to prevent that the grinding dust sticking to the top plate and the side plate of the grinding chamber may drop onto the upper surface of the workpiece. Further, the grinding water can be scattered in different directions from the plural through holes, so that the grinding water scattered can clean a wide area in the grinding chamber to thereby improve the cleaning efficiency for the grinding chamber.

In accordance with another aspect of the present invention, there is provided a cleaning method for a grinding chamber in a grinding apparatus including holding means for holding a workpiece and grinding means having a rotatable grinding wheel, the grinding wheel being composed of an annular base having an inner side surface and an outer side surface and a plurality of abrasive members fixed to the base and arranged annularly for grinding the workpiece held on the holding means, the holding means and the grinding means being provided in the grinding chamber, the cleaning method including: a grinding water supplying step of supplying a grinding water at given flow rate from grinding water supplying means to the inner side surface of the base of the grinding wheel in the condition where the grinding wheel is being rotated; and a grinding chamber cleaning step of guiding the grinding water supplied by the grinding water supplying step along the inner side surface of the base to the abrasive members, introducing a part of the grinding water into a plurality of through holes formed in the base so as to extend from the inner side surface to the outer side surface, by using a centrifugal force due to the rotation of the grinding wheel, and then scattering the grinding water from the through holes opening to the outer side surface, thereby cleaning the grinding chamber with the grinding water scattered.

With this configuration, the grinding water is scattered from the through holes of the grinding wheel to thereby

clean the grinding chamber, thereby preventing the adhesion of the grinding dust to the work surface of the workpiece.

The above and other objects, features and advantages of the present invention and the manner of realizing them will become more apparent, and the invention itself will best be understood from a study of the following description and appended claims with reference to the attached drawings showing some preferred embodiments of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic sectional view of a grinding apparatus according to a first preferred embodiment of the present invention;

FIG. **1**B is a schematic sectional view of grinding means included in the grinding apparatus shown in FIG. **1**A;

FIGS. **2**A and **2**B are schematic sectional views for illustrating the operation of the grinding apparatus according to the first preferred embodiment and the cleaning method for a grinding chamber included in the grinding apparatus shown in FIG. **1**A;

FIGS. **3**A and **3**B are schematic sectional views for illustrating the operation of a grinding apparatus according to a comparison;

FIGS. **4**A, **4**B, and **4**C are schematic sectional views showing various modifications of the grinding means according to the first preferred embodiment; and

FIG. **5** is a schematic sectional view of grinding means according to a second preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

There will now be described a grinding apparatus according to a first preferred embodiment of the present invention with reference to FIGS. **1**A and **1**B. FIG. **1**A is a schematic sectional view of the grinding apparatus according to the first preferred embodiment, and FIG. **1**B is a schematic sectional view of grinding means included in the grinding apparatus shown in FIG. **1**A. The configuration of the grinding apparatus according to the present invention is not limited to that shown in these drawings, but any configuration capable of grinding a workpiece with abrasive members may be adopted.

Referring to FIG. **1**A, the grinding apparatus generally denoted by reference numeral **1** includes a holding table **3** (holding means) for holding a workpiece W and grinding means **4** having a grinding wheel **5** with a plurality of abrasive members **60** for grinding the workpiece W held on the holding table **3**, wherein the holding table **3** is vertically opposed to the grinding means **4**. Each abrasive member **60** has a grinding surface **61** adapted to come into contact with the upper surface **10** (work surface) of the workpiece W held on the holding table **3**, thereby grinding the workpiece W. Further, the grinding apparatus **1** is configured in such a manner that a grinding water to be supplied to the abrasive members **60** is scattered to the outside of the grinding wheel **5**, thereby cleaning a grinding chamber **2**.

In the condition where the holding table **3** is located below the grinding means **4** so as to be opposed thereto as shown in FIG. **1**A, the grinding chamber **2** is defined by a cover member. This cover member is composed of an upper cover **21** for covering the upper and side areas of the grinding means **4** and a lower cover **22** for covering the periphery of the holding table **3**. The upper cover **21** includes a top plate **23** extending horizontally and a side plate **24** extending downward from one end of the top plate **23**. The top plate **23** has an opening **23***a* from which a part (spindle **41**) of the grinding means **4** projects upward. The lower cover **22** is composed of a peripheral cover **25** fixed to the outer circumference of the holding table **3** and a waterproof cover **26** extending horizontally below the peripheral cover **25**. The grinding chamber **2** is configured in such a manner that the grinding water containing a grinding dust generated during grinding does not splash out of the grinding apparatus **1** and that this grinding water can be drained from a predetermined position.

In the first preferred embodiment, examples of the workpiece W to be ground include a semiconductor wafer formed of a semiconductor material such as silicon and GaAs and an inorganic material wafer formed of an inorganic material such as ceramic, glass, and sapphire. Further, the workpiece W may be formed of various work materials required to have a TTV (Total Thickness Variation) on the order of microm-eters to submicrometers.

The holding table **3** is a disk-shaped member, and it is rotatably provided on a base (not shown). The holding table **3** has an upper surface functioning as a holding surface **31** for holding the workpiece W under suction. The holding surface **31** is formed of a porous ceramic material. While the holding surface **31** is shown as a flat surface in FIG. **1**A, the holding surface **31** is actually formed as a gently inclined conical surface having an apex coinciding with the center of rotation of the holding table **3**. Accordingly, when the workpiece W is held on the holding surface **31** under suction, the workpiece W such as a wafer having a small thickness is deformed into a gently inclined conical shape following the shape of the holding surface **31**.

The grinding means **4** includes the spindle **41** having a rotational axis extending vertically, a wheel mount **43** connected to the lower end of the spindle **41**, and the grinding wheel **5** mounted on the lower surface of the wheel mount **43**. The spindle **41** is rotationally driven by a motor **42**. The wheel mount **43** is fixed to the lower end of the spindle **41**. The grinding wheel **5** is detachably mounted on the wheel mount **43**. The grinding means **4** is vertically movable by elevating means (not shown) toward or away from the holding table **3**.

The wheel mount **43** is a disk-shaped member, and an annular recessed portion **44** is formed on the lower surface of the wheel mount **43** along the outer circumference thereof, wherein an annular base **50** constituting the grinding wheel **5** is fitted in the annular recessed portion **44**. The recessed portion **44** has a flat surface **45** as a mounting surface for mounting the base **50** and a cylindrical side surface **46** as a positioning surface for radially positioning the base **50**.

The plural abrasive members **60** constituting the grinding wheel **5** are fixed to the lower surface **54** of the annular base **50** so as to be annularly arranged. The annular base **50** is composed of an outer portion **51** and an inner portion **52** having a thickness smaller than that of the outer portion **51**. The annular base **50** has an upper surface **53** as a mounted surface to be mounted on the wheel mount **43**. Further, the outer portion **51** has a lower surface **54** and the inner portion **52** has a lower surface **55** higher in level than the lower surface **54**. The lower surface **54** of the outer portion **51** and the lower surface **55** of the inner portion **52** are connected to each other through an inner side surface **56** (conical surface) diverging from the lower surface **55** to the lower surface **54**. This inner side surface **56** functions as an inclined surface for guiding the grinding water to the abrasive members **60** as described later.

Each abrasive member **60** is formed by bonding alumina abrasive grains, silicon carbide abrasive grains, or superabrasive grains of CBN (Cubic Boron Nitride) or diamond, for example, with a bond such as resin bond and vitrified bond. In the condition shown in FIG. **1**A, the abrasive members **60** are located above the holding table **3** so that each abrasive member **60** can pass through the position directly above the axis of rotation of the holding table **3**. The grinding wheel **5** is fixed to the wheel mount **43** by tightening a plurality of screws **62** from the upper surface of the wheel mount **43** in the condition where the base **50** is fitted in the recessed portion **44** of the wheel mount **43**.

A first passage **64** for supplying the grinding water is formed in the spindle **41** so as to extend vertically along the axis of rotation of the spindle **41**. Grinding water supplying means **63** is connected to one end (upper end) of the first passage **64**. A plurality of second passages **65** for supplying the grinding water are formed in the wheel mount **43** and connected to the lower end of the first passage **64**. The second passages **65** extend horizontally from the center of the wheel mount **43** toward the outer circumference thereof in the radial direction of the wheel mount **43**. The radially outer ends of the second passages **65** are bent downward at the positions above the base **50** and respectively connected to a plurality of third passages **66** formed in the base **50**. Each third passage **66** is formed as a through hole extending from the upper surface **53** (mounted surface) of the base **50** to the lower surface **55** of the base **50** at the inner portion **52** thereof. These through holes as the third passages **66** are equally spaced in the circumferential direction of the base **50**.

Further, the outer portion **51** of the base **50** is formed with a plurality of through holes **58** and **59** extending from the inner side surface **56** (inclined surface) to the outer side surface **57**, wherein these plural through holes **58** and **59** are two kinds of through holes. The plural through holes **58** and **59** are equally spaced in the circumferential direction of the base **50** and alternately arranged. The through holes **58** are inclined upward from the inner side surface **56** to the outer side surface **57**, whereas the through holes **59** are formed below the through holes **58** and inclined upward from the inner side surface **56** to the outer side surface **57** at an inclination angle smaller than that of the through holes **58**.

In the condition where the grinding wheel **5** is being rotated during grinding, the grinding water is supplied at a predetermined flow rate from the grinding water supplying means **63**. The grinding water is supplied through the first, second, and third passages **64**, **65**, and **66** to the abrasive members **60**. At this time, a part of the grinding water is introduced into the plural through holes **58** and **59** formed in the base **50** by a centrifugal force due to the rotation of the grinding wheel **5** and next discharged (scattered) from the outer side surface **57** of the base **50** in a plurality of directions. This grinding water discharged from the outer side surface **57** of the base **50** is used as a cleaning water for cleaning the grinding chamber **2**.

In the condition where the grinding water is being supplied to the grinding wheel **5**, the grinding wheel **5** being rotated is lowered until the grinding surface **61** of each abrasive member **60** comes into contact with the upper surface **10** (work surface) of the workpiece W held on the holding table **3**. By making the contact between the abrasive members **60** and the workpiece W, the workpiece W is ground by the abrasive members **60**. At this time, the grinding dust generated during grinding is contained in the grinding water and forced to flow with the grinding water. Further, the grinding water containing the grinding dust also floats as a mist in the grinding chamber **2** and sticks to the top plate **23** and the side plate **24** of the grinding chamber **2**. However, the clean grinding water directly supplied from the grinding water supplying means **63** is discharged from the plural through holes **58** and **59** formed in the base **50** in this preferred embodiment. Accordingly, the grinding dust sticking to the top plate **23** and the side plate **24** can be washed away by the clean grinding water, so that there is no possibility that the grinding dust may drop onto the upper surface of the workpiece W.

The operation of the grinding apparatus **1** according to the first preferred embodiment and the cleaning method for the grinding chamber **2** will now be described by using a comparison with reference to FIGS. **2**A and **2**B and FIGS. **3**A and **3**B. FIGS. **2**A and **2**B are schematic sectional views for illustrating the operation of the grinding apparatus **1** according to the first preferred embodiment and the cleaning method for the grinding chamber **2**, wherein FIG. **2**A shows a condition before grinding and FIG. **2**B shows a condition during grinding. FIGS. **3**A and **3**B are schematic sectional views for illustrating the operation of a grinding apparatus according to the comparison, wherein FIG. **3**A shows a condition before grinding and FIG. **3**B shows a condition during grinding. The comparison shown in FIGS. **3**A and **3**B is different from the first preferred embodiment shown in FIGS. **2**A and **2**B in the point that the two kinds of through holes **58** and **59** are not formed in the base of a grinding wheel in the comparison.

The operation of the grinding apparatus **1** according to the first preferred embodiment will now be described. As shown in FIG. **2**A, the grinding water is supplied from the grinding water supplying means **63** to the grinding means **4** in the condition where the grinding wheel **5** is being rotated before grinding (grinding water supplying step). The grinding water is supplied through the first, second, and third passages **64**, **65**, and **66** to the inner portion **52** of the base **50** and next guided along the inner side surface **56** to reach the abrasive members **60**. Since the grinding wheel **5** is being rotated, the grinding water supplied to the abrasive members **60** is splashed obliquely downward toward the outside of the abrasive members **60** by a centrifugal force. Accordingly, the holding table **3**, the lower cover **22**, the side plate **24**, etc. located below the grinding means **4** can be cleaned by the clean grinding water before grinding.

Further, a part of the grinding water flowing downward on the inner side surface **56** is introduced into the plural through holes **58** and **59** formed in the outer portion **51** of the base **50**. The grinding water introduced into the plural through holes **58** and **59** is allowed to flow obliquely upward owing to the centrifugal force in the through holes **58** and **59** from the inner side surface **56** to the outer side surface **57** of the base **50**. Thereafter, the grinding water is discharged from the outer side surface **57** of the base **50** toward the outside of the grinding wheel **5** (grinding chamber cleaning step). In this case, the rotational speed of the grinding wheel **5** is adjusted so that the grinding water can flow obliquely upward in the upward inclined through holes **58** and **59** toward the outer side surface **57**. In other words, the component of the centrifugal force with respect to the directions of extension of the through holes **58** and **59** is larger than the component of the gravity acting on the grinding water with respect to the directions of extension of the through holes **58** and **59**.

The inclination angle of the through holes **58** is different from the inclination angle of the through holes **59**, and the outlets of the through holes **58** and **59** are formed at different positions on the outer side surface **57**. Accordingly, the

grinding water discharged from the outer side surface **57** is scattered at different angles. As a result, the grinding water can be widely scattered around the grinding means **4**. The grinding water thus scattered strikes the upper cover **21** to wash away the grinding dust or the like sticking to the top plate **23** and the side plate **24**. In this manner, the grinding water supplied to the grinding means **4** is used as a cleaning water for cleaning the grinding chamber **2** before grinding. By suitably changing the inclination angle, diameter, etc. of the through holes **58** and **59**, it is possible to freely adjust the flow rate, discharge direction, discharge distance, discharge speed, etc. of the grinding water to be scattered from the through holes **58** and **59**.

When the grinding wheel **5** is lowered from the condition shown in FIG. **2**A, the grinding surface **61** of each abrasive member **60** comes into contact with the upper surface **10** (work surface) of the workpiece W in the condition where both the grinding wheel **5** and the holding table **3** are being rotated, thereby grinding the workpiece W. The grinding dust generated during grinding is contained in the grinding water supplied along the abrasive members **60** to the workpiece W, and the grinding water thus containing the grinding dust is forced to flow radially outward on the upper surface **10** of the workpiece W. Thereafter, the grinding water containing the grinding dust is scattered from the outer circumference of the holding table **3** toward the lower cover **22**. Further, a part of the grinding water containing the grinding dust is bounced from the workpiece W to form a mist, which floats in the grinding chamber **2**.

As in the condition shown in FIG. **2**A, the clean grinding water is discharged from the plural through holes **58** and **59** toward the outside of the grinding wheel **5** during grinding as shown in FIG. **2**B. Accordingly, even when the grinding dust sticks to the top plate **23** and the side plate **24** of the grinding chamber **2**, the grinding dust can be washed away by the grinding water discharged from the through holes **58** and **59**. As a result, the grinding chamber **2** can be kept clean and it is possible to prevent that the grinding dust may drop from the top plate **23** to the upper surface **10** of the workpiece W. The vertical positions (heights) of the inlets of the plural through holes **58** and **59** opening to the inner side surface **56** of the base **50** are set so that the grinding water containing the grinding dust (see the hatched part of the grinding water shown in FIG. **2**B) does not enter the inlets of the through holes **58** and **59** after rising along the abrasive members **60** and the inner side surface **56** of the base **50**. Accordingly, only the clean grinding water (pure water) not containing the grinding dust is allowed to enter the inlets of the through holes **58** and **59**. As a result, the grinding chamber **2** can be cleaned by only the clean grinding water.

In the first preferred embodiment, the grinding water supplying step is defined as the step of supplying the grinding water from the grinding water supplying means **63** to the grinding means **4** in the condition where the grinding wheel **5** is being rotated. Further, the grinding chamber cleaning step is defined as the step of supplying the grinding water along the inner side surface **56** of the base **50** to the abrasive members **60**, introducing a part of this grinding water into the through holes **58** and **59** from their inlets opening to the inner side surface **56**, and then discharging the grinding water from the outlets of the through holes **58** and **59** opening to the outer side surface **57**, thereby cleaning the grinding chamber **2**. In the cleaning method for the grinding chamber **2** according to the first preferred embodiment, the cleaning chamber **2** can be cleaned by both the grinding water supplying step and the grinding chamber cleaning step.

The cleaning step for the grinding chamber **2** according to the first preferred embodiment may be performed before grinding or may be performed during grinding. In the case of performing the cleaning step for the grinding chamber **2** before grinding, the grinding dust or the like left on the inner wall of the grinding chamber **2** can be washed away by the grinding water to thereby prevent the adhesion of the grinding dust to the upper surface **10** of the workpiece W. In the case of performing the cleaning step for the grinding chamber **2** during grinding, the grinding dust generated during grinding can be washed away by the grinding water to thereby maintain the grinding chamber **2** in a clean condition. Further, the cleaning step for the grinding chamber **2** may be performed in the condition where the workpiece W is not held on the holding table **3**. In this case, the holding surface **31** of the holding table **3** can be cleaned to thereby prevent the entry of the grinding dust between the holding surface **31** and the workpiece W. Accordingly, there is no possibility of damage to the workpiece W due to the grinding dust.

The grinding apparatus according to the comparison shown in FIGS. **3**A and **3**B will now be described. As shown in FIG. **3**A, the grinding apparatus generally denoted by reference numeral **101** is different from the grinding apparatus **1** shown in FIG. **1**A in the point that no through holes are formed in a base **104** so as to extend from an inner side surface **105** to an outer side surface **106**. Accordingly, a grinding water supplied to grinding means **103** is guided along the inner side surface **105** to abrasive members **107** and then only splashed obliquely downward from the abrasive members **107**, so that an upper cover **109** cannot be cleaned by the grinding water.

When the grinding means **103** is lowered as shown in FIG. **3**B, the abrasive members **107** come into contact with the workpiece W held on a holding table **102**, thereby grinding the workpiece W. As described above with reference to FIG. **2**B, the grinding dust generated during grinding is contained in the grinding water and then forced to flow away from the upper surface **10** of the workpiece W together with the grinding water. However, a part of the grinding water containing the grinding dust is bounced from the workpiece W to form a mist, which floats in a grinding chamber **102** and sticks to the upper cover **109**. Since the upper cover **109** cannot be cleaned by the grinding water as described above, there is a possibility that the grinding dust sticking to the upper cover **109** may drop onto the upper surface **10** of the workpiece W, causing damage to the upper surface **10** of the workpiece W or a grinding surface **108** of each abrasive member **107**.

To the contrary, the grinding apparatus **1** according to the first preferred embodiment includes the through holes **58** and **59** formed in the base **50** so as to extend from the inner side surface **56** to the outer side surface **57**, so that the upper cover **21** forming the grinding chamber **2** can be cleaned by the grinding water discharged from the through holes **58** and **59**. Accordingly, it is possible to prevent that the grinding dust may drop from the upper cover **21** to the upper surface **10** of the workpiece W.

In the grinding apparatus **1** according to the first preferred embodiment as described above, a part of the grinding water supplied toward the abrasive members **60** is guided along the inner side surface **56** of the base **50** and introduced into the through holes **58** and **59** by a centrifugal force due to the rotation of the grinding wheel **5**. The grinding water introduced into the through holes **58** and **59** is discharged from the outer side surface **57** of the base **50**. Accordingly, the grinding water passed through the through holes **58** and **59**

is scattered into the grinding chamber **2** to thereby wash away the grinding dust sticking to the top plate **23** and the side plate **24** of the grinding chamber **2**. As a result, it is possible to prevent that the grinding dust sticking to the top plate **23** and the side plate **24** may drop onto the upper surface **10** of the workpiece W. Further, the grinding water can be scattered in different directions from the plural through holes **58** and **59**, so that the grinding water scattered can clean a wide area in the grinding chamber **2** to thereby improve the cleaning efficiency for the grinding chamber **2**.

Various modifications of the through holes **58** and **59** formed in the base **50** will now be described with reference to FIGS. **4**A, **4**B, and **4**C. FIG. **4**A shows grinding means **4** according to a first modification, FIG. **4**B shows grinding means **4** according to a second modification, and FIG. **4**C shows grinding means **4** according to a third modification. In FIGS. **4**A to **4**C, the same parts as those of the first preferred embodiment shown in FIG. **1**B are denoted by the same reference numerals. The modifications shown in FIGS. **4**A to **4**C are different from the first preferred embodiment shown in FIG. **1**B in the direction of extension of the through holes. The following description will be focused on this different point.

As shown in FIG. **4**A, the grinding means **4** according to the first modification includes a plurality of through holes **58** formed in the base **50** so as to horizontally extend from the inner side surface **56** to the outer side surface **57**. These plural through holes **58** are equally spaced in the circumferential direction of the base **50**. These plural through holes **58** are formed at three different heights and arranged so as to form a wave. With this arrangement, the grinding water as a cleaning water can be scattered horizontally at three different heights.

As shown in FIG. **4**B, the grinding means **4** according to the second modification includes a plurality of through holes **58** and **59** formed in the base **50** so as to extend from the inner side surface **56** to the outer side surface **57**, wherein these plural through holes **58** and **59** are two kinds of through holes. These plural through holes **58** and **59** are equally spaced in the circumferential direction of the base **50** and alternately arranged. The through holes **58** are inclined upward from the inner side surface **56** to the outer side surface **57**. The through holes **59** are formed below the through holes **58** and inclined downward from the inner side surface **56** to the outer side surface **57**. With this arrangement, the grinding water can be scattered to the outside of the grinding wheel **5** in an obliquely upward direction and in an obliquely downward direction.

As shown in FIG. **4**C, the grinding means **4** according to the third modification includes a plurality of through holes **58** and **59** formed in the base **50** so as to extend from the inner side surface **56** to the outer side surface **57** as in the second modification. That is, these plural through holes **58** and **59** are equally spaced in the circumferential direction of the base **50** and alternately arranged. Furthermore, the upper through holes **58** are inclined upward from the inner side surface **56** to the outer side surface **57**, whereas the lower through holes **59** are inclined downward from the inner side surface **56** to the outer side surface **57**. With this arrangement, the grinding water can be scattered to the outside of the grinding wheel **5** in an obliquely upward direction and in an obliquely downward direction. However, in the third modification, the inlets of the through holes **58** and **59** opening to the inner side surface **56** are formed at the same height in an uppermost area on the inner side surface **56**. Accordingly, the grinding water containing the grinding dust can be prevented from entering the inlets of the through holes **58** and **59** after rising along the inner side surface **56** during grinding. As a result, only the clean grinding water supplied from the grinding water supplying means **63** can be scattered from the through holes **58** and **59**.

As described in the modifications shown in FIGS. **4**A to **4**C, the grinding water can be scattered to a desired position by suitably changing the position, number, inclination angle, etc. of the through holes **58** and **59**. Accordingly, the cleaning area, range, etc. in the grinding chamber **2** can be freely adjusted according to the shape of the grinding chamber **2**.

There will now be described grinding means according to a second preferred embodiment of the present invention with reference to FIG. **5**. FIG. **5** is a schematic sectional view of the grinding means according to the second preferred embodiment. The grinding means shown in FIG. **5** is grinding means for so-called TAIKO (registered trademark) grinding, wherein this grinding means is different from the grinding means according to the first preferred embodiment in the point that the outer diameter of a grinding wheel is smaller than the radius of a workpiece. The following description will be focused on this different point. The term of "TAIKO grinding" mentioned above means a grinding method such that the workpiece is ground except its peripheral area to thereby form an annular projection in this peripheral area. With this structure, the strength of the workpiece as a whole can be increased to thereby prevent the warpage of the workpiece and any trouble in handling the workpiece.

As shown in FIG. **5**, the grinding means generally denoted by reference numeral **204** includes a spindle **241**, a disk-shaped wheel mount **243** mounted on the lower end of the spindle **241**, and a grinding wheel **205** mounted on the lower surface of the wheel mount **243**. The grinding means **204** is vertically movable by elevating means (not shown) toward or away from a holding table (not shown). The grinding means **204** is also movable by horizontally moving means (not shown) in the radial direction of the holding table.

The wheel mount **243** is a disk-shaped member, and a circular recess **244** is formed on the lower surface of the wheel mount **243** at its central portion. Accordingly, the lower surface of the wheel mount **243** has an annular surface **245** around the circular recess **244**. This annular surface **245** functions as a mounting surface for mounting the grinding wheel **205**. The grinding wheel **205** is composed of a base **250** having a circular shape as viewed in plan and a plurality of abrasive members **260** fixed to the lower surface **254** of the base **250** at its peripheral portion. A circular projection **251** is formed on the upper surface of the base **250** at its central portion, and this circular projection **251** is fitted in the circular recess **244** of the wheel mount **243**. The diameter of the circular projection **251** is slightly smaller than the diameter of the circular recess **244**. By fitting the circular projection **251** in the circular recess **244**, the base **250** is radially positioned with respect to the wheel mount **243**.

A circular recess **252** is formed on the lower surface **254** of the base **250** at its central portion, wherein the diameter of the circular recess **252** is larger than the diameter of the circular projection **251**. Accordingly, the lower surface of the base **250** has an annular surface **254** around the circular recess **252**. This annular surface **254** functions as a mounting surface for mounting the plural abrasive members **260** in a ring fashion. In mounting the grinding wheel **5** to the wheel mount **243**, the circular projection **251** of the base **250** is fitted in the circular recess **244** of the wheel mount **243**, and a plurality of screws **262** are tightened from the bottom surface **253** (upper surface as viewed in FIG. **5**) of the

circular recess **252** of the base **250** into the wheel mount **243**, thereby fixing the base **250** to the wheel mount **243**.

A first passage **264** for supplying a grinding water is formed in the spindle **241** and the wheel mount **243** so as to extend vertically along the axis of rotation of the spindle **241**. Grinding water supplying means **263** is connected to one end (upper end) of the first passage **264**. A plurality of second passages **265** for supplying the grinding water are formed in the base **250** and connected to the lower end of the first passage **264**. The second passages **265** extend horizontally from the center of the base **250** toward the outer circumference thereof in the radial direction of the base **250**. The radially outward ends of the second passages **265** are bent downward at the positions radially inside the screws **262**. The lower ends of the second passages **265** open to the bottom surface **253** of the circular recess **252** of the base **250**.

The base **250** has a cylindrical inner side surface **256** formed by the circular recess **252** and an annular projection **255** formed around the circular recess **252**. The annular projection **255** is formed with a plurality of through holes **258** and **259** extending from the inner side surface **256** to the outer side surface **257**, wherein these plural through holes **258** and **259** are two kinds of through holes. The plural through holes **258** and **259** are equally spaced in the circumferential direction of the base **250** and alternately arranged. The through holes **258** are inclined upward from the inner side surface **256** to the outer side surface **257**, whereas the through holes **259** are formed below the through holes **258** and inclined slightly downward from the inner side surface **256** to the outer side surface **257**.

Also in the grinding means **204**, the grinding water supplied from the grinding water supplying means **263** can be scattered in plural directions from the plural through holes **258** and **259** to the outside of the grinding wheel **205**, thereby widely cleaning a grinding chamber (not shown). The TAIKO grinding is performed by the contact of the abrasive members **260** and a workpiece (not shown) in the condition where the grinding wheel **5** and the holding table holding the workpiece are rotated and the grinding means **204** is moved in the radial direction of the holding table.

The present invention is not limited to the above preferred embodiments, but various modifications may be made. The size, shape, etc. of the parts in the above preferred embodiments shown in the attached drawings are merely illustrative and they may be suitably changed within the scope where the effect of the present invention can be exhibited. Further, the above preferred embodiments may be suitably modified without departing from the scope of the object of the present invention.

For example, while the grinding water is discharged from the two kinds of through holes to the outside of the grinding wheel in the above preferred embodiments, the configuration of the through holes is not limited. That is, any kind of through holes capable of discharging the grinding water to the outside of the grinding wheel may be adopted. For example, one kind of through holes or three or more kinds of through holes may be adopted. Further, the shape and number of the through holes are not limited. Further, while the through holes for scattering the grinding water are formed in the base in the above preferred embodiments, the through holes may be formed in the grinding wheel.

In addition, while the inlets of the plural through holes **58** and **59** opening to the inner side surface **56** are formed at the same height in the modification shown in FIG. **4**C, this configuration is merely illustrative. For example, the inlets of the plural through holes **58** and **59** opening to the inner side surface **56** may be formed at different heights and the outlets of the plural through holes **58** and **59** opening to the outer side surface **57** may be formed at the same height.

The present invention is not limited to the details of the above described preferred embodiments. The scope of the invention is defined by the appended claims and all changes and modifications as fall within the equivalence of the scope of the claims are therefore to be embraced by the invention.

What is claimed is:

1. A cleaning method for a grinding chamber in a grinding apparatus including holding means for holding a workpiece and grinding means having a rotatable grinding wheel, the grinding wheel being composed of an annular base having an inner side surface and an outer side surface and a plurality of abrasive members fixed to the base and arranged annularly for grinding the workpiece held on the holding means, the holding means and the grinding means being provided in the grinding chamber, the cleaning method comprising:

a grinding water supplying step of supplying a grinding water at given flow rate from grinding water supplying means to the inner side surface of the base of the grinding wheel in the condition where the grinding wheel is being rotated; and

a grinding chamber cleaning step of guiding the grinding water supplied by the grinding water supplying step along the inner side surface of the base to the abrasive members, introducing a part of the grinding water into a plurality of through holes formed in the base so as to extend from the inner side surface to the outer side surface at an upward angle away from the workpiece, by using a centrifugal force due to the rotation of the grinding wheel, and then scattering the grinding water from the plurality of through holes opening to the outer side surface, thereby cleaning the grinding chamber with the grinding water scattered.

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